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THE EXTENT OF THE ANDERDON BEDS OF ESSEX COUNTY, ONTARIO, AND THEIR PLACE IN THE GEOLOGIC COLUMN.

REV'D THOMAS NATTRESS.

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With Compliments of
The Author

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THE EXTENT OF THE ANDERDON BEDS OF ESSEX COUNTY, ONTARIO, AND THEIR PLACE IN THE GEOLOGIC COLUMN.

REV'D THOMAS NATTRESS.

Considerable interest has centered in the Anderdon Limestone Beds of Anderdon Township, Essex County, Ontario, since Grabau pronounced them hitherto unrecognized in 1907 and gave to the beds the name they now bear. That interest was intensified by Professors Sherzer and Grabau when they claimed to have identified this limestone with certain problematical beds deep down in the Silurian strata in the Salt Shaft at Sout [illegible]

A year ago [illegible] ng before the Academy a paper on The Contour of the Sylvan [illegible] and Related Strata in the Detroit River Area, I took occasi [illegible] some suggestive evidence that the supposed intercalated b [illegible] the salt shaft and the Anderdon beds have each their own independent horizon.

Since then it has fallen to my lot to superintend the taking out of thirty drill cores to determine the extent of these limestone beds in Anderdon and Malden townships. Ten other cores had already been taken out in and near the Amherstburg Quarries in Anderdon. In addition to these forty drill cores, there are three quarry holes through the high grade limestone, to facilitate the estimate. The accumulated evidence has too broad a bearing not to be presented in the endeavor that has been yours and mine to solve the problems of the Detroit river area.

Professor Grabau has himself differentiated the Anderdon limestone in his Stratigraphic and Palaeontologic Summary of the Monroe Formation. Under the head of *"Upper Monroe Faunas" he groups as a unit the faunas of the Flat Rock, Anderdon and Amherstburg (Detroit river bottom) beds. Of the faunas of this supposed unit he has said: "Its most characteristic feature is its Devonic element." And: "If the fauna were considered by itself it would probably be pronounced a Scoharie or an Onondaga fauna without a moments hesitation, though there is a considerable Siluric element."

Taking the cut on p. 541 of the "Proceedings of the Albuquerque Meeting, (Fig. I. — Section of the Detroit river)," as setting forth the supposed relationship of the "Flat Rock, Anderdon coral limestone and Amherstburg Dolomite," the Flat-Rock below, the Amherstburg Dolomite above, the Anderdon between, —— then the "considerable Siluric element" ought to be very evident in the sandwiched Anderdon limestone in order that it should still persist in the overlying new-named Amherstburg. But whereas the Siluric fauna characterizes the Flat Rock and the Amherstburg Dolomite of the Detroit river bottom, it is characteristically absent from the Anderdon limestone beds.

Moreover, the Anderdon beds do *not* extend across Detroit river from the Amherstburg quarry to the Sibley quarry as figured in the cut referred to. This I have contended before and shall be able to set forth further evidence. The Dundee (Corniferous) limestone does *not* extend westward to the Detroit river as thus figured, and *does* form the surface extension over the great part of the Amherstburg quarry in Anderdon, where the cut shows only Anderdon coral limestone —— out of relation.

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*The Monroe Formation; Mich. Geolog. and Biolog. Survey, 1909, p 217.

Analyzing Grabau's faunal unit, this result is obtained:

Flat Rock Dolomite:

Stromatoporoidea, 0.
Brachiopoda, 0.
Pelecypoda, 0.
Cephalopoda, 0.
Annelida, 0.
Anthozoa, 3.
Bryozoa, 0.
Gastropoda, 0.
Trilobitae, 0.

The Anderdon Limestone:

Stromatoporoidea, 6.
Brachiopoda, 2.
Pelecypoda, 1.
Cephalopoda, 0.
Annelida, 0.
Anthozoa, 12.
Bryozoa, 0.
Gastropoda, 2.
Trilobitae, 0.

The Amherstburg Bed (dolomite) of Detroit River:

Stromatoporoidea, 2.
Brachiopoda, 12.
Pelecypoda, 3.
Cephalopoda, 4.
Annelida, 1.
Anthozoa, 13.
Bryozoa, 1.
Gastropoda, 8.
Trilobitae, 1.

Of the *Stromatoporoidea* 2 of 6 are in common between the Anderdon limestone and the Amherstburg dolomite.

Of *Anthozoa* there is 1 in common throughout, and but 4 in common between the Anderdon limestone and the Amherstburg dolomite, out of a total of 21.

Of *Brachiopoda* there is but 1 of 13 in common between the Anderdon limestone and the Amherstburg dolomite.

Bryozoa is represented in the Amherstburg dolomite alone.

Of *Pelecypoda* but 1 out of 3 is in common between the Anderdon and the Amherstburg.

Of *Gastropoda* there is nothing in common, though 10 species have been noted.

Cephalopoda, *Trilobitae* and *Annelida* are represented in the Amherstburg only, in *Grabau's list. I have since found *Proetus crassimarginatus*, in the Anderdon limestone.

I submit that here is an internally exclusive "unit."

Nor is that the end of the comparison. Of 23 species (5 genera) identified in the Anderdon limestone and the coral bed of the salt shaft at

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*Michigan Geological and Biological Survey, 1909, The Monroe Formation, —— Grabau and Sherzer.

Delray, but 7 are in common to these, one only of which is found in the dolomite of the Detroit river bed in the vicinity of Amherstburg.

Having presented *evidence to show what the Anderdon limestone beds are not, I shall attempt to show what these beds are,—how they are deposited, and how they are related.

THE MALDEN VALLEY.

The drill holes put down to determine the extent of the Anderdon limestone have disclosed a basin and a valley leading to it from the south, together containing the "Anderdon Beds" (Grabau). I have presumed to name this valley the Malden Valley of the Anderdon Limestone, inasmuch as it was first followed up from a starting point in Malden township. I have followed up this valley some 6,500 feet from that starting point of investigation to where it expands into a basin, the central area of which is the Amherstburg Quarry property.

Cross sections prove the valley formation and show the relation of the Anderdon Beds to the underlying Silurian dolomites. A complete cross section is constituted by test holes numbered 9 to 13, from east to west.

In No. 9, in an old Detroit river channel, there is a Silurian surface extension. Analyses show an average of 56.75 $CaCO_3$.

About 800 feet west of it No. 10 showed Anderdon Beds at the surface, one foot in depth, resting upon a transitional rock, which in turn rests upon Silurian dolomite. The transitional here averages 60.56 $CaCO_3$, and is 8 feet in depth; the dolomite 54.19 tested to a depth of 21 feet.

No. 11 is about 700 feet west of No. 10: Anderdon 13 feet, averaging 93.76 $CaCO_3$; Transitional, 8′ 6″, 63.37; Silurian dolomite 5′ 10″, 54.87.

No. 12, about 700 feet west of No. 11, shows 10′ 7″ of Anderdon, averaging 95.60 $CaCO_3$; Transitional, 7′ 9″, 62.44; dolomite not penetrated.

No. 13 is about 700 feet west of No. 12. Here there is but 2 feet of Anderdon Beds, averaging 94.72 $CaCO_3$; Transitional 7′ 5″, averaging 57.53; Silurian dolomite penetrated 11′ 7″, averaging 50.39 $CaCO_3$.

Some 6,000 feet west of No. 13 is the Detroit river bed, with Silurian dolomite extension,—a surface that would probably extend as a surface extension as far east of Detroit river as to a point 300′ to 400′ west of No. 13 test hole.

A review of this cross section shows:

(1) The Anderdon Beds in the Malden Valley banking up against Silurian dolomite, east and west;

(2) A Silurian surface extension both east and west of the Anderdon Beds, in the old Detroit river channel eastward and in the bed of the present Detroit river westward; and, on reference to elevations,

(3) A Silurian dolomite synclinal between the Canadian channel of Detroit river immediately opposite Amherstburg (elevation 552.5 +) and No. 10 test hole, (elevation of Silurian surface, 563.2) in close proximity to the eastern edge of the Anderdon;

(4) A similar syncline east of that again, immediately; (5) Disturbance of former levels prevailing during the time of depositing of the

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*See Michigan Academy of Science report, 1910. "The Contour of the Sylvania Sandrock and Related Strata in the Detroit River Area."

Transitional overlying the dolomite, during which time the present Silurian syncline was at least 700 feet wider than it is now, on the east side—for within that approximate distance the Transitional (of which there is 8 feet in depth at No. 10 hole,) has shored up;

(6) Maximum thrust of uplift in close neighborhood of No. 10;

(7) Change in elevations across the whole cross section distance of the Anderdon beds, with possible exception of the extreme western shore; and

(8) Suggests the reason for the prevailing increased depths of boulder till from the eastern limit of the Malden Valley of Anderdon limestone, westward to Detroit river,—an ascertained increase of depth of from 12′ 0″ to 15′ 6″ to 21′ 3″ to 28′ 6″ to 40′ 0″ at intervals of about 700 feet.

TRANSITIONAL ROCK.

The characteristics of the Transitional rock at the base of the Anderdon limestone, and the reasons for describing it as transitional are these:

(1) It lies between a limestone deposit of the purest quality and an equally pronounced Silurian dolomite, and is itself a dolomitic limestone.

(2) It is not local but extends over the whole area of, and beyond the outer edges of, the overlying Anderdon limestone; requiring, therefore, consideration as a distinct deposit; and having characteristics that relate it to both the Devonian and the Silurian.

(3) Like the Anderdon limestone above it, this rock carries the Devonian form of calcium carbonate crystal, dog-tooth spar, by contrast with the Silurian scalenohedra of calcite.

(4) Yet, in several instances, and at low horizons in the formation the crystals filling the cavities of the rock appeared to be a compromise between the two forms.

(5) In addition to that fact, the prevailing browns, blue-grays, and the dullness of the grays and drabs are Silurian characteristics.

(6) There were no Silurian forms distinguishable, nor either sulphate or carbonate of strontia, nor any gashed or acicular rock; all of which, with scalenohedra of calcite and high magnesia characterize the underlying strata.

(7) There is, as in the Silurian, at many elevations, considerable dark-lined lamination and frequent irregular lines of deposit.

(8) In three instances only does the $CaCO_3$ average of the transitional rock from a given test hole fall below 60%, and that where too few samples were taken. From all the rest of twenty-one averages the percentage of calcium carbonate is from 60.56 to 69.04. The average over all—in a distance of two miles—is 63.49 $CaCO_3$. This fact establishes the Transitional as a better calcium carbonate rock than is the heavy-bedded dolomitic limestone which lies second above it and forms the base of the Corniferous. This latter dolomitic limestone analyses about 60% $CaCO_3$. [illegible], the Transitional appears to be almost fossil free.

I submit that this rock is transitional in character, with predominating Devonic features.

Before considering the question of transitional rock at further length let me present some facts of

THE BASIN OF ANDERDON LIMESTONE,

of which the Amherstburg quarry property forms the central area.

Thus far—except in viewing the entire distance of the Transitional—only the Malden Valley of Anderdon beds has been considered, by way of which the supply of this limestone seems to have come in from the south'ard.

The Amherstburg Quarry basin of Anderdon limestone is an expansion of the Malden Valley, circular in form, with a bulging western side. It seems to have had no other communication with the outer sea, in Anderdon time, than this valley. Cross sections will show the manner of deposit to best advantage. Two will suffice, one from east to west, and one from N. x NW. to S. x SE. Test* holes 26, "3," "8," and 21 are from east to west in order. No. "8" is as nearly as may be the center of the basin. No. 26 marks the eastern limit of the deposit. No. 21 is 1,500 feet west of this center and No. "3" is 1,350 feet east of center. Were there one more test made as far west of center as No. 26 is east of it, at the rate at which the depth lessens westward there would probably be about the same depth of Anderdon beds in that as there is in No. 26.

No. 20 test was the most westerly put down and though somewhat out of line for this cross section is yet available for comparison. (It is also interesting as establishing a bulging west side.)

Anderdon at 26, 1′ 3″,
Anderdon at "3," 16′ 7″,
Anderdon at "8," 28′ 0″,
Anderdon at 21, 15′ 9″,
Anderdon at 20, 6′ 2″.

This section shows an east and west shoreing up of Anderdon high grade limestone.

A MODIFIED ANDERDON.

During Anderdon time, and while these beds were being deposited, extraneous influences were exerted upon the Anderdon material about the outer edges of the basin, sometimes reaching across its full width—or rather would I say, meeting in the centre. Just what these influences were is not so easy to say. The effect exerted is very palpable. In some cases several feet in depth of the Anderdon beds are reduced to the quality of an ordinary good limestone; in other cases a silicated limestone was produced; in still other cases the slow depositing limestone has been swamped with magnesia and silica until a dolomite resulted. Whether the magnesia and silica were due to an inwash from a Silurian sea to the west, north, northeast and east, facilitated by a lowering of the confining Silurian anticlinal dam by earth movements from time to time, alternating with unlift; or whether the source of the extraneous matter was a Silurian land area, may be open to question. Very considerable depths of unmodified pure Anderdon limestone alternate with deteriorated parts. Especially is this true toward the centre of the basin, indicating that the influence was one felt chiefly along shore.

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*Plain figures indicate tests of the survey of Sept. to Dec., 1910; figures in quotation indicate tests of 1909 survey.

The silication is not so difficult to account for. In part it is from the same source without doubt. But when it is observed that the most heavily silicated spots are on the shoulders of the Malden Valley where it expands into the basin, and also directly in line with the slight wash from the inflow of the valley, the chief cause of silication has been identified. The valley itself has felt none of these influences to any perceptible degree.

Should it be that the magnesian influence was due to the sea, then it follows that Silurian conditions prevailed northward, westward and to the northeast whilst the Malden Valley communicated with a sea to the south in which Devonian conditions had already become established.

A N. x N. NW. to S. x S. SE. Cross Section shows the same basin formation, with No. "8" test hole as centre, four tests to the southeastward of it and two to the northwestward. (In no case has the west side been tested out to the same extent as the rest of the area, because of heavily increased depth of boulder till.)

The test holes of this cross section are, in order from S. x S. SE. to N. x N. NW., Nos. 15, 17, 22, "9," "8," "4" and "5." The distances between, in same order, approximately 1,000′, 450′, 425′, 525′, 1,725′, and 330′.

Anderdon at 15, 0′ ½″,
Anderdon at 17, 5′ 6″,
Anderdon at 22, 23′ 6″,
Anderdon at "9," 42′ 0″,
Anderdon at "8," 28′ 0″,
Anderdon at "4," 11′ 3″,
Anderdon at "5," 8′ 6″.

Modified Anderdon at 15, 0′ 0″,
Modified Anderdon at 17, 22′ 1″,
Modified Anderdon at 22, 22′ 10″,
Modified Anderdon at "9" 9′ 0″,
Modified Anderdon at "8" 23′ 6″,
Modified Anderdon at "4" 29′ 4″
Modified Anderdon at "5" 27′ 0″.

Transitional Rock at 15, 3′ 8″,
Transitional Rock at 17, 10′ 6″,
Transitional Rock at 22, 4′ 6″ +,
Transitional Rock at "9" 8′ 0″,
Transitional Rock at "8" 11′ 6″,
Transitional Rock at "4" 4′ 8″,
Transitional Rock at "5" Not penetrated.

The Anderdon shows distinctly the basin shape of deposit. On comparing the Anderdon + Modified Anderdon depths in No. "8" and No. "9," it will be noted that No. "9" has felt the deteriorating influences much less than the No. "8" area. It shows less Modified Anderdon and more high-grade limestone. Consequently, whether at base or surface, the Modified Anderdon also shows the basin form of deposit in the cross section.

A consideration of the elevations in the same test holes in the same order gives the same results:

Elevation of Anderdon at 15, 570.36 A. T.
at 17, 570.63,
at 22, 566.00,
at "9," 558.26,
at "8," 547.50,
at "4," 576.15, and
at "5," 563.80;

Elevation of Modified Anderdon:
at 17, 565.13,
at 22, 543.50,
at "9," 526.26,
at "8," 519.50,
at "4," 564.90, and
at "5," 553.30;

Elevation of Transitional Rock:
at 15, 570.32,
at 17, 543.05,
at 22, 519.66,
at "9," 507.26,
at "8," 496.00,
at "4," 535.56,
at "5," not penetrated.

The basin, as shown by elevations of the Anderdon at No. 15 and No. "5"—has a lip rim, occasioned by uplift of the inner area in relation to the outer.

The evenness of the basin shape is evident if it be remembered that the distance from No. "8" to No. "4," 1,725 feet, is more than three times any other separating distance; that Nos. 17 and 15 are 1,000 feet apart; and that another test is needed about 350 feet N. x N. NW. of No. "5" to contrast with No. 15 at extreme S. x S. SE., for a complete comparison.

A cross section from NE. to SW., from the Sol White quarry hole, by way of the Amherstburg quarry limestone cut, test holes No. "8" and No. "7," to No. 20 shows the same basin-shaped deposit.

EARTH MOVEMENTS OVER THE ANDERDON AREA.

The evidences of earth movement over the Anderdon limestone area during Transitional, Anderdon and Corniferous time are of very pronounced character.

Included in the transitional rock shown up by cross section of the Malden Valley already presented, is a deposit characterized by quantities of calcium carbonate crystal, in bulk, so to say. In drill core No. 10 this is 48 inches in depth; in No. 11, 700 feet west it is 36 inches in depth; in No. 12, 700 feet west of No. 11, there is but 26 inches; and in another 700 feet it has disappeared. This assuredly indicates one of two things: a deep side to the valley—which does not seem to account for all the facts in the case; or a gradual change of elevation during continuance of the deposit.

Subsequent to Anderdon time, and in what has hitherto been recognized as mid-Corniferous, a movement of a different kind has taken place. This time it is not tilting, but there appears to have been a thrust that reached its maximum along the eastern side of the Anderdon deposit—both valley and basin. The evidence is of two kinds: (1) *Change of elevation along cross section lines, and (2) a shattered condition of the eastern edge of the deposit. Every cross section shows a gradual slope to westward across the entire width of what must, in the order of things, have been a slightly concaved surface at the close of Anderdon time. In the Amherstburg quarry basin of the Anderdon material this movement is evidenced by relative differences of elevation, though the basin surface is still preserved in any but an east and west section.

SINK HOLES.

The shattered condition of the eastern edge of the Anderdon deposit is evidenced by a series of twenty or more sink holes in the land surface. In localities these are grouped together in numbers. In every case where the rock below has been investigated it has been found to be fissured and broken. Along the west side of the deposit the depth of stripping impervious to water would in itself explain the absence of sink holes. There does not, however, appear to be the same shattered condition of the rock, though the core-drill occasionally revealed a crack.

A LINE OF FAULT.

Associated with this line of sink-holes, and parallel with it, is a series of mineral springs highly charged with sulphur, that would seem to show a line of fault. This line traverses the old Detroit river channel immediately east of the Malden Valley of Anderdon limestone where the surface extension is entirely of Silurian dolomite.

THE MAXIMUM OF THRUST.

When the depositing of Anderdon sediment ceased, it would seem to be evidenced by a maximum depth of overlying Corniferous that the lowest elevation within the Anderdon basin—and approximately the center of the basin—corresponded closely with No. "8" test hole, at which spot there is still the lowest elevation (547.50) of Anderdon within the basin.

And at this precise spot the Corniferous has a higher elevation than any other part of the entire surface in question—unless it be between No. "8" and No. "9" which, together with it, has felt the maximum of thrust. The disturbed elevation of the Corniferous surface of itself proves

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*Test holes 10 to 13, 2100 feet from east to west, show elevations of Anderdon beds: 571.30, 567.80, 561.85, and 554.50.

Test holes 29 and 27, in east to west section, 700 feet, show 574.40 and 563.90. Nos. 15 and 16, 780 feet east to west, 570.36 and 565.70. Test holes "1," "9," "7," and 19 and 20 show 574.33, 558.25, 538.10, 536.66 and 536.66.

earth movement. (Ascertained elevations: 578.26, 584.50, 561.10, 555.60, and 538.00.)

If there has been any earth movement strictly within Anderdon time the evidence is to be found in the Modified Anderdon. If that modification was due to movement and not to the influence of an adjacent land area round about the basin, then it proves in that case a successive lowering and raising of the surrounding Silurian dam that confined the Anderdon waters and excluded—except by intervals—the waters of a sea in which older conditions still persisted.

THE DEPTH OF BOULDER TILL.

The depth of boulder till on the Detroit river side of the line of highest elevations throughout the length of the Anderdon deposit, stands definitely related to the interposed rock barrier to the ice sheet in its forward movement. From east to west across the basin, 3,300 feet, the [*]depths of till are these:

10′ 2″, 14′ 0″, 21′ 6″, 32′ 6″, 50′ 0″.

Along the [†]complete cross section of the valley, east to west 2,100 feet: 12′ 0″, 15′ 6″, 21′ 3″, 28′ 6″, and, in another 1,000 feet westward along the Silurian dolomite surface, 40′ 0″.

On the other hand the glacial detritus has banked up against this same barrier on the east side of it, giving depths in [‡]reverse order: 28′ 6″, and 10′ 2″; 17′ 0″ and 9′ 0″.

We have thus, doubtless, come upon the explanation of the old Detroit river channel already named: First, a shallow Silurian synclinal dip; then a rock elevation interposed in the path of the glacier, consisting of a low Silurian anticlinal bank, with Transitional and Anderdon rock superimposed, and all of this elevated by a thrusting movement.

CORNIFEROUS AND ANDERDON MATERIAL.

All the Anderdon limestone material seems to have come in from the south, as has been already stated. Because of the greater depth of the deposit within the cul de sac basin as compared with the supplying valley from the south another valley was suspected leading to the eastward from the basin. That side also was thoroughly tested in the hope of finding such a valley. There is a valley—but not of the supposed age. It carries only Corniferous material. That there is a valley of shallow dimensions goes to show a slight letting down of a surrounding anticlinal tongue of Silurian age which has admitted the Corniferous sediment from the eastward, none of which came in by way of the Malden Valley; around the tip of which upward fold of Silurian, and toward the south, the Anderdon has circled about, with normal depth, to cross Detroit river in the neighborhood of the upper end of Grosse Isle where there is a showing of Corniferous at the surface, to be again quarried, in its normal depth, in the bottom of the Sibley quarry, almost opposite the phenomenal depth in the Amherstburg quarry.

A cross section of the whole Detroit river area between these two quarries would show nothing of the Anderdon beds from shore to shore of the river. Much less would such cross section show the Detroit river bottom bed of dolomite to overlay Anderdon limestone—to which river bottom strata Grabau and Sherzer have given the name of Amherstburg Dolomite. Neither will it show Sylvania Sandrock at the base of Flat Rock dolomite over this area. Nor are the strata of the Detroit river series of Upper Monroe age, except in the upper reaches of the river; and except as the Upper Monroe strata round the head of the extreme northerly limit of the Cincinnati anticline and circle back to south'ard. On the contrary, and with the exception noted, the characteristics of these strata are those of the Lower Monroe. Compared with the Ballville section of the Ohio Greenfield dolomite this rock also is* "a light-colored dolomitic calcilutite." Like the Lower Monroe beds of Maryland these beds also are †"nearly all calcilutites, mostly thin-bedded, well stratified." As in the case of the Raisin River dolomite, at a given horizon *"hemispherical masses protrude . . . having a finely laminated, concentric structure and apparently concretionary in their structure;" and, "locally the beds contain patches of iron pyrite." The upper beds are almost fossil-free, which will not be said to be a characteristic of the Upper Monroe strata. And, in addition, the sharp directly southward dip of the strata in all the central part at least of the area in question is in itself a statement of the fact that here is the rock against which the Upper Monroe banks, stratum upon stratum, with dip swinging from westward to northward in Monroe and Wayne counties.

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[*] Test holes "1," "9," "7," 19 and 20.

[†] Test holes 10, 11, 12, 13, and the Borrowman well.

[‡] Test holes Nos. 26 and "1"; Nos. 5 and 29.

One further remark about the age of the Anderdon limestone beds. Professor Grabau has emphasized their Devonic affinities. I have shown that these beds do not sandwich between two dolomities; that they rest upon a dolomitic limestone transitional in character and Devonic in its chief characteristics; and that they are Devonic in chemical properties, analyzing in some instances 99.55 $CaCO_3$. And, whereas †Grabau describes "the Monroe beds and underlying formations (as) all involved in slight folding *which took place in post-Monroe and pre-Dundee times,*" I have shown the Anderdon limestone beds occupying the synclinal space between two of these lateral folds.

Altogether it would appear that the Anderdon Limestone beds have been wrongly classed as Siluric; in short that they are of Devonic age.

Amherstburg, Ontario, March 28th, 1911.

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*Stratigraphy, Structure and Local Distribution of the Monroe Formation; by Professors W. H. Sherzer and A. W. Grabau.

† "Correlation of the Monroe Formation of Michigan, Ohio and Canada with the Upper Siluric of Eastern North America and elsewhere," Mich. Geolog. Survey, 1909. The Monroe Formation.